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First records of *Hylaeus* (*Paraprosopis*) *pictipes* Nylander, 1852 (Hymenoptera: Colletidae) in North America

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Abstract. Cavity-nesting bees, such as members of the genus *Hylaeus* Fabricius (Hymenoptera: Colletidae), are prone to accidental introductions by human-mediated transportation. The first records of *Hylaeus* (*Paraprosopis*) *pictipes* Nylander, 1852 in North America are reported. *Hylaeus pictipes* is a European species newly discovered from Mississauga, Ontario, Canada; Meadville, Pennsylvania, USA; and Cleveland, Ohio, USA. Notes on its identification and a discussion of exotic bees in North America are provided.

Key words. Adventive species; Apoidea; bees; distribution; Hylaeinae

The number of adventive bee species in North America continues to grow (Linsley 1958; Cane 2003; Sheffield et al. 2011; Martins et al. 2017; Normandin et al. 2017) and their abundance in collections have increased as they establish (Bartomeus et al. 2013). *Hylaeus* Fabricius nest in pre-existing cavities (Michener 2007), which makes them readily transportable by human means. For example, two European species of *H.* (*Spatulariella*), *H. hyalinatus* Smith, 1842 and *H. punctatus* (Brullé, 1832), have recently become established in North America, particularly in urban areas, and their ranges are expanding (Snelling 1983; Ascher 2001; Ascher et al. 2006; Sheffield et al. 2011; Ksiazek et al. 2014; MacIvor & Packer 2015). *Hylaeus* (*Indialaeus*) *strenuus* (Cameron, 1897), an Indian species, has become established in Hawaii (Magnacca et al. 2011, 2013). Another exotic species, *H.* (*Hylaeus*) *communis* Nylander, 1852, with potential to spread widely in North America, has just been documented in Canada (Martins et al. 2017).

We report the first records of another introduced species in North America: *Hylaeus* (*Paraprosopis*) *pictipes* Nylander, 1852. *Hylaeus pictipes* is native to Europe (Fig. 1) from Portugal to the Caucasus (Dathe 1980; Dathe et al. 2016). Nests are made in pre-existing cavities such as plant stems of *Ailanthus* Desf., *Rubus* L. or *Lonicera* L. and provisioned using multiple floral hosts (Koster 1986; Westrich 1990; Janvier 2012).

Collections and photographs of bees were made in a suburban area of Mississauga, Ontario, Canada, (43.5883, –79.6036) on the afternoon of 17 August 2015 (Fig. 2). Specimens of *Hylaeus* were collected from *Daucus carota* L. in the backyard of a private residence using an aerial net and cyanide kill jar. A single male of *H. pictipes* was collected and the specimen is deposited at the J. B. Wallis/R. E. Roughley Museum of Entomology (JBWM), University of Manitoba (JBWM0363000). Twenty-one additional specimens were collected on 5 August 2016 in an adjacent parking lot (43.5885, –79.6037), using identical techniques. These specimens are also deposited at the JBWM (JBWM0363001-JBWMJ0363019) with the exception of 1 male and female deposited at the A. J. Cook Arthropod Research Collection, Michigan State University (MSUC; no voucher numbers). Five additional specimens, 1 female and 4 males, from Meadville, Pennsylvania (41.6516, –80.1461) are also at JBWM (JBWM0363020-JBWM0363024). These specimens were brought to the attention of the lead author by Sam Droege (Patuxent Wildlife Research Center, United States Geological Survey). Additional specimens from Cleveland, Ohio were subsequently identified by S. Droege from collections at Ohio State University (OSU; Table 1) and examined by JG from photographs. Distribution maps (Figs. 1, 2) were made using map data downloaded from http://www.geographynetwork.ca/ and

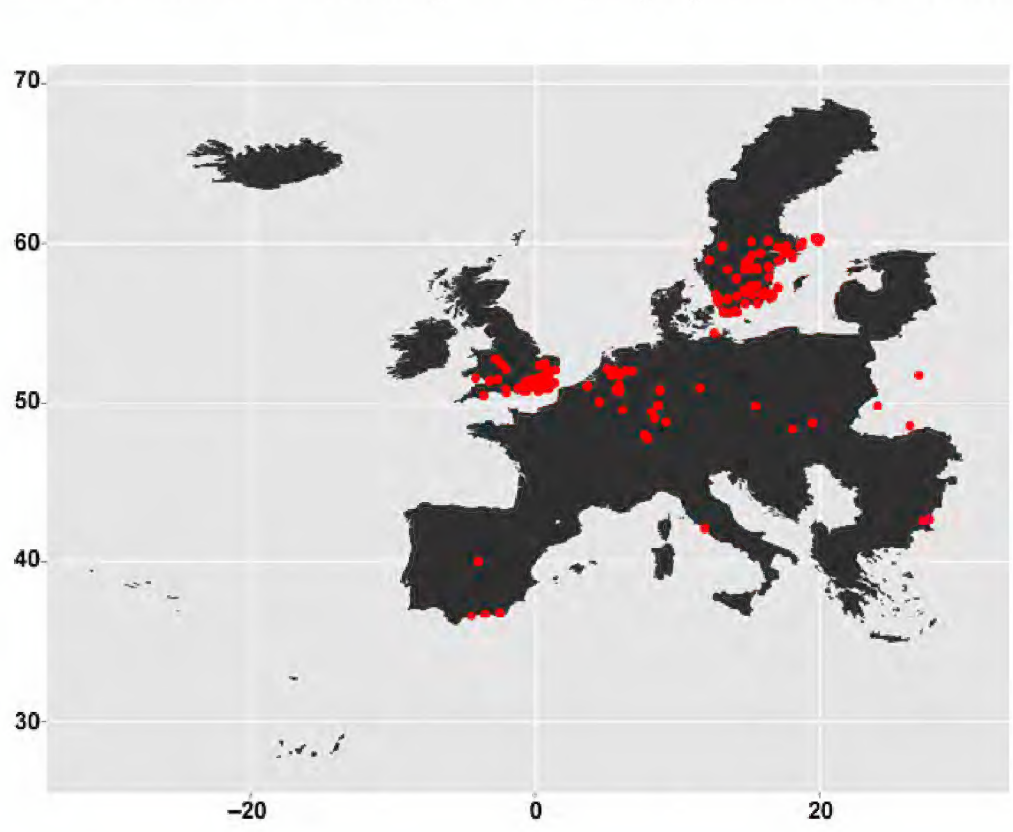

Figure 1. Distribution map of *Hylaeus* (*Paraprosopis*) *pictipes* Nylander in its native European range.

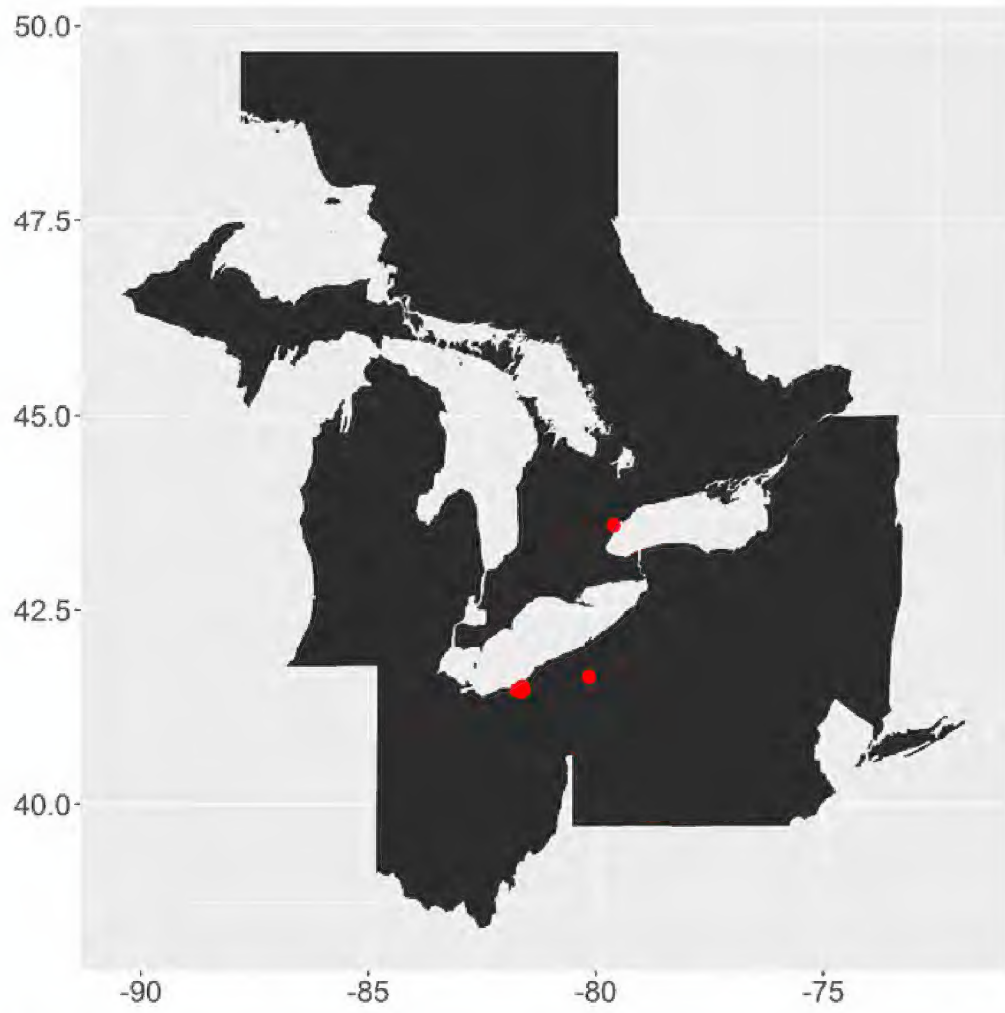

Figure 2. New North American distribution records of *Hylaeus* (*Paraprosopis*) *pictipes* Nylander in southern Ontario, Pennsylvania, and Ohio. New York State and Michigan included for reference.

the R package *maps* (Becker et al. 2016) with historical specimen records from GBIF.org (28 May 2016), GBIF Occurrence Download http://doi.org/10.15468/dl.logdbd, and analyzed in R (R Core Team 2015) using the packages *ggplot2* (Wickham 2009) and *rgdal* (Bivan et al. 2016).

Images of the live bee (Fig. 3) were taken in the field using a Canon T3i with a 100 mm macro lens and 25 mm extension tube. Subsequently, auto-montaged photos of preserved specimens were taken using a Canon 70d with MPE-65 mm macro lens using a Stackshot system and combined with Zerene Stacker. Additional material collected from the native range was used for comparison.

A single male specimen was collected and photographed (Fig. 3) in 2015. At the time of collection, the novelty of the specimen was not recognized, so additional collections were not attempted. Only when the specimen was examined at a later date was it noted that it did not match any known specimen from the region (Mitchell 1960; Snelling 1966, 1970; Romankova 2007). The original male specimen was tentatively identified as *H. pictipes* using Koster (1986). Owing to uncertainty in the identification, images of the specimen were shared with local experts before the specimen, with genitalia dissected (Fig. 4A), was ultimately sent to HHD for confirma-

Table 1. New records of *Hylaeus* (*Paraprosopis*) *pictipes* Nylander in North America

Voucher number	Depository	Country	Region	Latitute	Longitude	Date	No.
JBWM0363000	JBWM	Canada	Ontario	43.5883	−81.6036	17 Aug 2015	1
JBWM0363001-JBWM0363519	JBWM	Canada	Ontario	43.5885	−81.6037	5 Aug 2016	19
(none)	MSUC	Canada	Ontario	43.5885	−81.6037	5 Aug 2016	2
JBWM0363023-JBWM0363024	JBWM	USA	Pennsylvania	41.6516	−80.1461	30 Jul–1 Aug 2015	2
JBWM0363020-JBWM0363021	JBWM	USA	Pennsylvania	41.6422	−80.1486	15–17 Jul 2016	2
JBWM0363022	JBWM	USA	Pennsylvania	41.6545	−80.1392	15–17 Jul 2016	1
PN-1131, PN-1132	OSU	USA	Ohio	41.4574	−81.634	14 Aug 2015	2
16-237	OSU	USA	Ohio	41.4617	−81.635	9 Jun 2016	1
15-874	OSU	USA	Ohio	41.4622	−81.6331	5 Aug 2015	1
16-652	OSU	USA	Ohio	41.4622	−81.6331	8 Aug 2016	1
357	OSU	USA	Ohio	41.4639	−81.6394	31 Jul 2014	1
16-29	OSU	USA	Ohio	41.4640	−81.6377	9 Jun 2016	1
16-366	OSU	USA	Ohio	41.4640	−81.6377	26 Jul 2016	1
15-186	OSU	USA	Ohio	41.4640	−81.6370	6 Jul 2015	1
16-41	OSU	USA	Ohio	41.4640	−81.6370	9 Jun 16	1
N16-572, N16-588, N16-595, N16-604, N16-609	OSU	USA	Ohio	41.4677	−81.7041	5 Jul 2016	5
N16-427	OSU	USA	Ohio	41.4677	−81.7041	21 Jun 2016	1
PN-965	OSU	USA	Ohio	41.4680	−81.7020	13 Aug 2015	1
N16-674	OSU	USA	Ohio	41.4680	−81.7020	5 Jul 2016	1
PN-340	OSU	USA	Ohio	41.4735	−81.5965	10 Jul 2015	1
N16-1426	OSU	USA	Ohio	41.4749	−81.7391	4 Aug 2016	1
N16-1214, N16-1216	OSU	USA	Ohio	41.4804	−81.6086	3 Aug 2016	2
PN-1184	OSU	USA	Ohio	41.4813	−81.5967	14 Aug 2015	1
PN-393, PN-402	OSU	USA	Ohio	41.4813	−81.5967	10 Jul 2015	2
N16-1267	OSU	USA	Ohio	41.4898	−81.6294	3 Aug 2016	1
N16-913	OSU	USA	Ohio	41.4916	−81.6068	6 Jul 2016	1
N16-246	OSU	USA	Ohio	41.4916	−81.6068	14 Jun 2016	1
PN-1497	OSU	USA	Ohio	41.4977	−81.6602	17 Aug 2015	1
PN-1390, PN-1391	OSU	USA	Ohio	41.4990	−81.6280	16 Aug 2015	2
N16-1010	OSU	USA	Ohio	41.4990	−81.6280	7 July 2016	1
PN-1591, PN-1595	OSU	USA	Ohio	41.5111	−81.6291	17 Aug 2015	2
N16-1329	OSU	USA	Ohio	41.5111	−81.6291	4 Aug 2016	1
N16-1056, N16-1057	OSU	USA	Ohio	41.5165	−81.6351	7 July 2016	2
N16-17, N16-20, N16-49	OSU	USA	Ohio	41.5233	−81.6180	10 Jun 2016	3
PN-1677	OSU	USA	Ohio	41.5250	−81.6200	19 Aug 2015	1

Figure 3. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. First male collected in Mississauga, Ontario, Canada, nectaring on *Daucus carota* L. (JBWM0363000). **A.** Oblique frontal view. **B.** Oblique dorsal view.

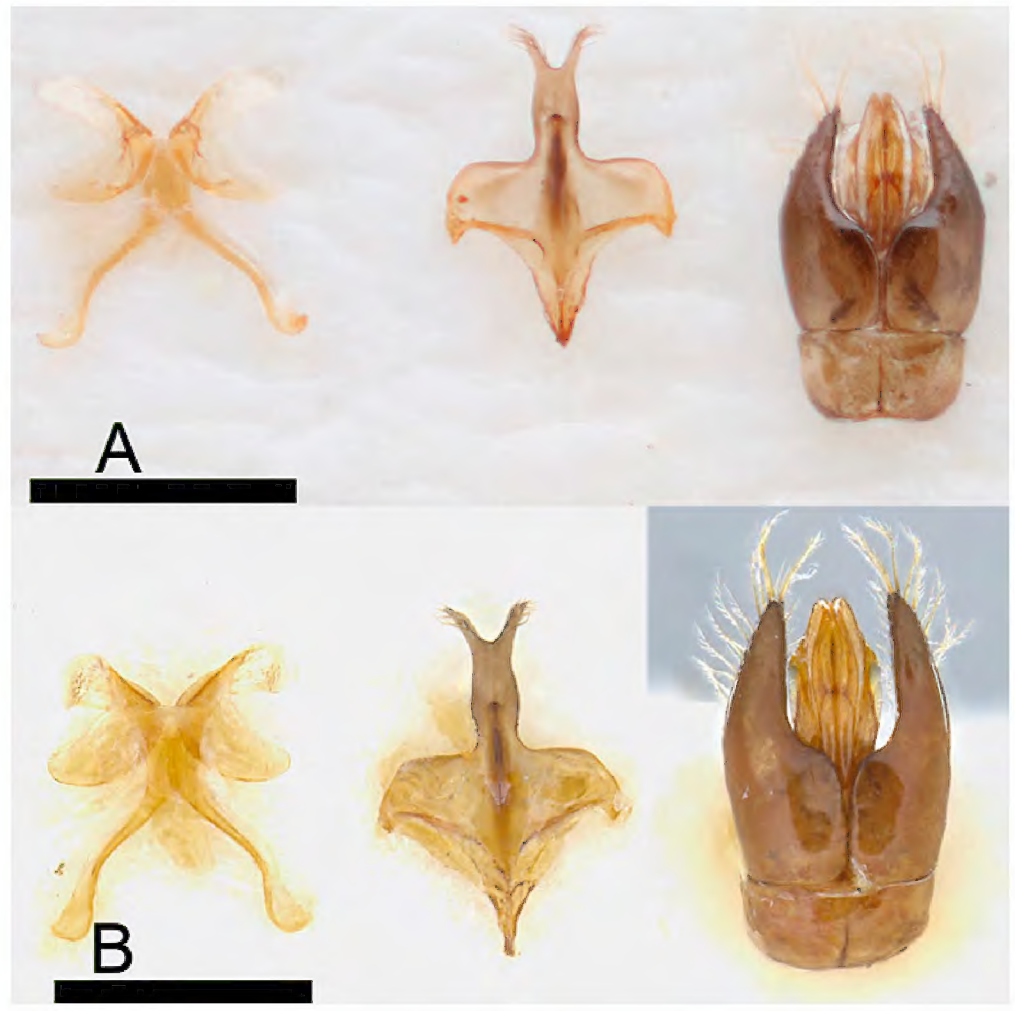

Figure 4. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. Terminalia of male. From left to right, S7, S8 and genital capsule. A) Male from Mississauga, Ontario (JBWM0363000). B) Male from Europe. Scale bars = 1 mm.

tion. In 2016, after the identification of the original specimen, 13 additional males (Figs. 5A, 6) and 8 females (Figs. 7A, 8) were collected from a neighbouring lot to the original collection site. Both sexes key to the subgenus *H.* (*Paraprosopis*) in subgeneric keys to the *Hylaeus* of the Western Hemisphere and Palaearctic Region (Michener 2007). Sixteen members of the subgenus *Hylaeus* (*Paraprosopis*) are native to Canada and the United States, but are primarily restricted to the western United States (Snelling 1970; Ascher & Pickering 2016). Three native species of *H.* (*Paraprosopis*) occur in Canada, *H. coloradensis* (Cockerell, 1896), *H. nevadensis* (Cockerell, 1896), and *H. wootoni* (Cockerell, 1896), but none of these are found in Ontario or the eastern United States. In eastern North America, the native species *H.* (*Paraprosopis*) *floridanus* (Robertson, 1893) ranges north to states adjacent to Ontario, including Michigan, and *H.* (*Paraprosopis*) *georgicus* (Cockerell, 1898) is native to southeastern United States (Mitchell 1960; Snelling 1970). The species does not match any of the species of *H.* (*Paraprosopis*) included in Snelling (1970). The specimens were compared directly to 10 species of North American *H.* (*Paraprosopis*) identified by Roy Snelling deposited at MSUC, including all species previously known from Canada and the eastern United States. In the male, the pale off-white maculations of the face in combination with the maculations on the scape (Fig. 5A) are reminiscent of *H.* (*Hylaeus*) *leptocephalus* (Morawitz, 1871), an apparently naturalized species in North America that originated in the Palaearctic region over a century ago (Snelling 1970; Sheffield et al. 2011). However, in *H. pictipes* the structure of the face and fine punctation of the mesopleuron are quite unlike the longer face and coarse punctation of *H. leptocephalus*. The male would run to *H.* (*Prosopis*) *affinis* (Smith, 1853) in Mitchell (1960) based on the pale scape. However, some European *H. pictipes* have the scape dark (Fig. 5B), which would run to *H.* (*Paraprosopis*) *floridanus*. To aid in identification, the genitalia and hidden sternites of the original male collected were dissected out and glued to a small card below the specimen (Fig. 4A). The pointed structure of the gonoforceps are characteristic of this species (Dathe 1980; Dathe et al. 2016). Males of *H. floridanus* differ in the shape of S8, having the paired apical lobes less even in size, the posterior most lobe being much larger (Mitchell 1960; Snelling 1970). In *H. pictipes*, the paired lateral lobes of S8 are similar in size (Fig. 4).

The female would run to *H. floridanus* in Mitchell (1960), but European specimens with a black pronotal collar and maculated tegula would likely run to *H.* (*Hylaeus*) *mesillae* (Cockerell, 1896) *cressoni* (Cockerell, 1907) (as *H. cressoni*) or near *H.* (*H.*) *verticalis* (Cresson, 1869). In Romankova (2007), the male would likely run to *H.* (*Prosopis*) *modestus* Say, 1837, but the female would not key out well to any species. The female can be separated from other Ontario species by the facial fovea curving strongly away from the compound eye, ending at about the midpoint between the eye and lateral ocellus. Most North American females examined have distinct yellow maculations on the clypeus (Fig. 7A), but this is variable for the species (Fig. 7B). The female can be distinguished from *H. floridanus* using the following characters: paraocular maculation truncated below, not reaching to mandible; mesopleuron and mesoscutellum appearing smoother due to less microsculpture.

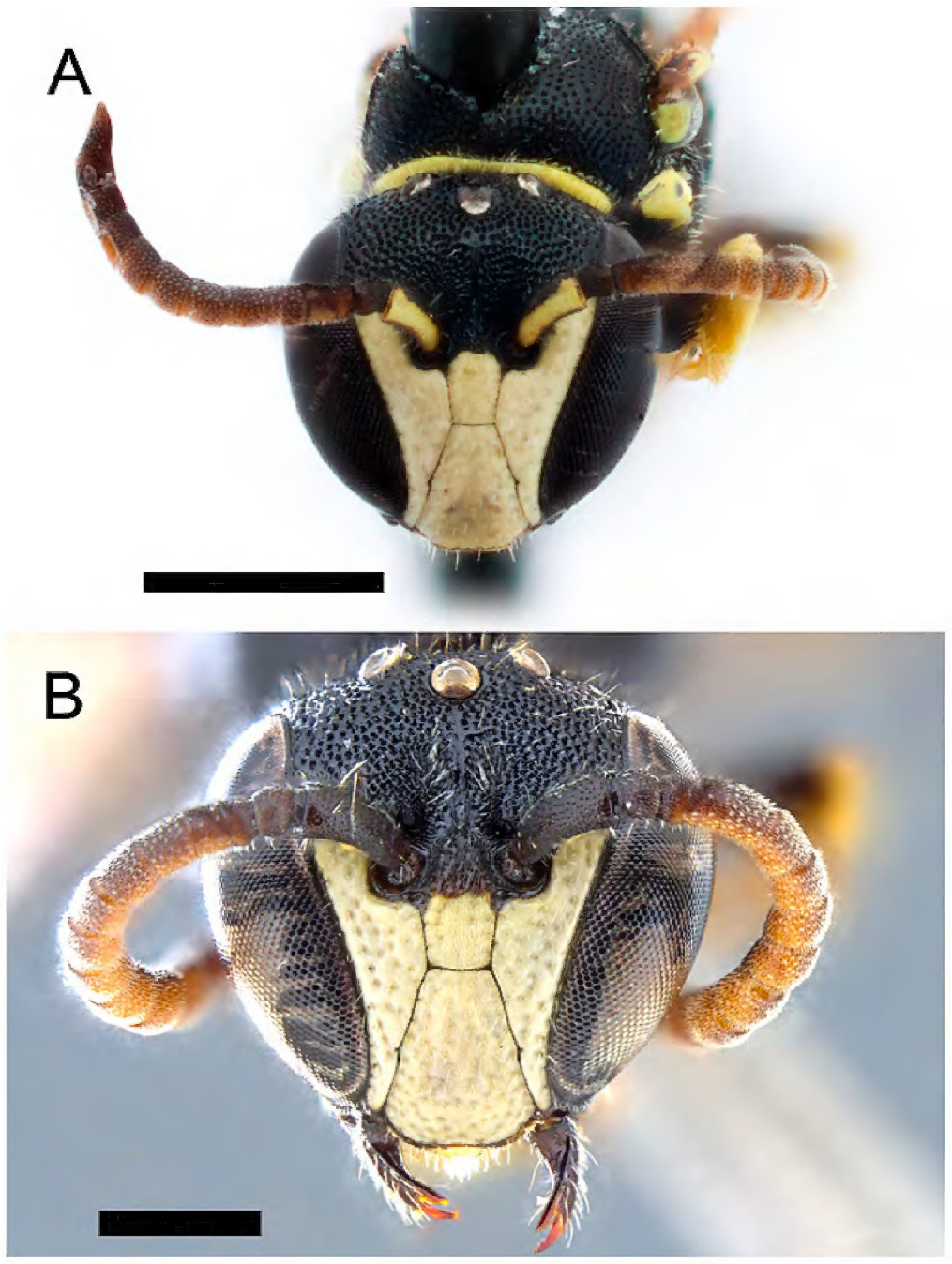

Figure 5. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. A) Face of male from Mississauga, Ontario, Canada (JBWM0363010). Scale bar = 1 mm. B) Face of male from Europe. Scale bar = 0.5 mm.

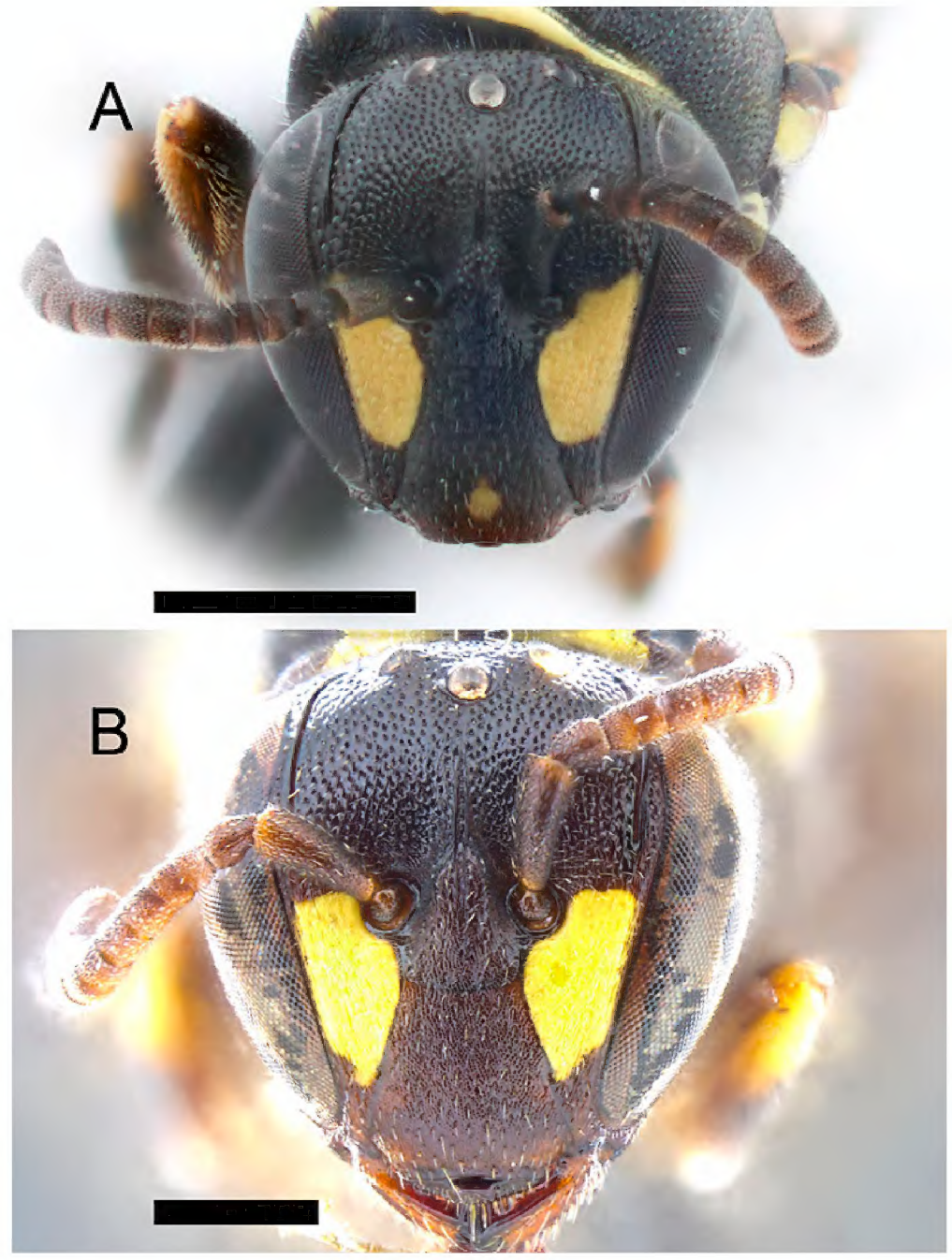

Figure 7. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. **A.** Face of female from Mississauga, Ontario, Canada, showing facial fovea ending halfway between eye and ocellus (JBWM0363015). Scale bar = 1 mm. **B.** Face of female from Europe. Scale bar = 0.5 mm.

Figure 6. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. Lateral habitus of male from Mississauga, Ontario, Canada (JBWM0363010). Scale bar = 1 mm.

Figure 8. *Hylaeus* (*Paraprosopis*) *pictipes* Nylander. Lateral habitus of female from Mississauga, Ontario, Canada (JBWM0363015). Scale bar = 1 mm.

The first records of *Hylaeus pictipes* in the New World, collected from Mississauga, Ontario, Canada, (43.5883, –79.6036; 43.5885, –79.8037), and Meadville, Pennsylvania and Cleveland Ohio, USA are presented here (Fig 1). The native range of *H. pictipes* is largely restricted to more northern parts of Europe, up to 60° N in Sweden, extending east to the Caucasus (Dathe et al. 2016) and south to the Iberian Peninsula. These new records are more than 4000 km from the nearest record in the Azores (Weissmann et al. 2017). The wide distribution of *H. pictipes* in Europe (Fig. 2) suggests it may thrive under a breadth of climate conditions in North America. *Hylaeus pictipes* is polylectic in its native range, foraging on at least seven plant families (Koster 1986; Westrich 1990), including plants occurring in North America, such as *Aegopodium podagraria* L., *Anethum graveolens* L., *Daucus carota, Heracleum* sp., (Apiaceae), *Sedum acre* L. (Crassulaceae), *Reseda lutea* L. (Resedaceae), and *Rubus* spp. (Rosaceae). It nests in

a broad range of existing cavities, including beetle burrows, hollow and pithy stem, earthen holes, and man-made materials (Scheuchl & Willner 2016). Exotic *Hylaeus* (*Spatulariella*) species that have been recently recorded from eastern North America (Ascher 2001; Ascher et al. 2006), have expanded their range extensively in less than a decade (Sheffield et al. 2011; Ksiazek et al. 2014). *Hylaeus leptocephalus* has been in Canada and the United States for at least a century and has spread across the continent (Snelling 1970). Based on other exotic cavity-nesting bees introduced to North America (Hinojosa-Díaz 2008; Gibbs & Sheffield 2009; Strange et al. 2011), these range expansions of exotic *Hylaeus* are expected to continue. The first recognized specimen of *H. pictipes* was in 2015, but it is now known from two additional sites south of Lake Erie separated by more than 200 km from the Mississauga records. The major trade route from the St. Lawrence River through Lake Ontario and Lake Erie is an important source for non-native species (Pagnucco et al. 2015), and other new records of adventive bees have been first discovered in this region (Sheffield et al. 2010, 2011; Martins et al. 2017; Normandin et al. 2017). A DNA-barcoded specimen of *H. pictipes* from southern California (www.boldsystems.org) requires additional verification, but if validated would indicate a much more extensive range for this species in North America.

The abundance of exotic species in collections has risen (Bartomeus et al. 2013), and this may come at the expense of native species. The ecological impacts of introduced bees remain poorly studied (Goulson 2003), although there have been reported cases of direct competition for nesting sites between exotic and native species (Laport & Minckley 2012; Roulston & Malfi 2012). Competition for floral resources and nesting sites creates potential for negative impact on native species (Goulson 2003). Introduction of pests and pathogens with exotic species is of concern (Hedtke et al. 2015; Cameron et al. 2016), but there are no studies of pathogens in introduced *Hylaeus* species. Should they occur, closely related species are most likely to be susceptible to introduced pathogens. Additional monitoring in the Great Lakes Region and urban areas of neighbouring states is needed to monitor the potential spread of this introduced species and to better document the current state of the native *Hylaeus* fauna.

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